

Mapping the Chemical Composition of Subchondral Bone in Osteoporosis Using Infrared Microscopy

M. Chance and R. Huang (Albert Einstein College of Medicine) L. Miller (Brookhaven National Laboratory) C. Carlson (U. of Minnesota)

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We are examining the chemical composition of bone from the knee joints of cynomolgus monkeys. A comparison is being made between "intact" monkeys (Sham-ovariectomized) and ovariectomized monkeys. An extensive clinical database is available for all animals, including bone densitometry, CT scan, and bone biomarker data. The ovariectomized monkeys show a marked reduction in bone mass, consistent with osteoporosis.

Although it is clear that bone mass is significantly reduced in osteoporosis, it is unclear whether bone that is formed differs from normal bone. This issue is extremely important because chemical composition of bone not only affects its strength and flexibility, but also influences the process of remodeling because it affects hydroxyapatite crystal size, density, and solubility.

Infrared microspectroscopy is being used to compare variations in bone morphology with bone compositional features such as protein/mineral ratios, mineral crystallinity, protein composition, and mineral composition. Comparisons are made between (1) normal vs. osteoporotic bone, (2) cortical vs. cancellous bone, and (3) "old" bone vs. "new" bone.

To date, we find that the overall degree of mineralization, represented by the ratio of carbonate to amide I band, is higher in normal monkeys than those with osteoporosis. Greater variability in mineralization is also observed in osteoporotic bone. Based on these data, we propose a model in that the increased resorption process in osteoporosis replaces regions of bone with young, immature bone. Compensatory bone formation increases the degree of mineralization of the older bone, and hence contributes to the greater variability. We are now studying the bone mineral as well as matrix composition by deconvoluting the subcomponents of carbonate, phosphate, and amide bands. The effects of nandrolone decanoate, an anabolic steroid known to increase body mass, on the chemical content of bone are also studied using the same experimental controls.